The Respiratory Response to Changing Temperature in Millipedes belonging to the Genus *Glomeris* Latreille, 1802

Vladimir SUSTR

Institute of Soil Biology, Academy of Sciences of the Czech Republic, 370 05 Ceske Budejovice, Czech Republic

ABSTRACT

The relationship between respiration rate and temperature of 3 millipede species: *Glomeris marginata* (Villers, 1789), *Glomeris hexasticha* Brandt, 1833 and *Glomeris balcanica* (Verhoeff, 1906), with different geographical distribution was measured and analysed. Simple linear relationship was found in *G. marginata*. A zone of the relative independence of respiration rate on temperature in the temperature range 15-20°C was observed in *G. hexasticha*. The zone was less apparent in *G. balcanica*. Specific respiration rates were higher in males than in females in all species. Possible ecological significance of the difference in the respiration-temperature dependence was discussed.

RÉSUMÉ

Réponse respiratoire aux changements de température chez les diplopodes du genre *Glomeris* Latreille, 1802.

Les relations entre le métabolisme respiratoire et la température ont été mesurées et analysées chez trois espèces de diplopodes présentant des aires de répartition différentes : *Glomeris marginata* (Villers, 1789), *Glomeris hexasticha* Brandt, 1833 et *Glomeris balcanica* (Verhoeff, 1906). Une relation linéaire simple a été mise en évidence chez *G. marginata*. Chez *G. hexasticha*, le métabolisme respiratoire est relativement indépendant de la température, entre 15°C et 20°C, phénomène moins évident chez *G. balcanica*. Pour toutes les espèces, les taux respiratoires sont plus élevés chez les mâles que chez les femelles. La possibilité d'une interprétation écologique de cette différence dans la relation respiration-température est discutée.

INTRODUCTION

Glomeris balcanica is a dominant species of the soil macrofauna in extreme biotopes on an altitudinal gradient on Mt. Olympus and in a *Quercus coccifera* formation in Northern Greece. The detailed description of its biology and ecology, including respiration activity, was given by IATROU (1989) and IATROU & STAMOU (1989). *Glomeris marginata* is a common inhabitant of litter layers in deciduous forests of western Europe, *Glomeris hexasticha* is a middle and east European species. The biology and ecology of *G. marginata* and *G. hexasticha* was described by DUNGER & STEINMETZGER (1981). More information about respiration-temperature relationships have been published (e.g. PENTEADO & MENDES, 1981; GROMYSZ-KALKOWSKA & TRACZ, 1983). However, different authors have used different experimental conditions, so

SUSTR, V., 1996. — The respiratory response to changing temperature in millipedes belonging to the genus *Glomeris* Latreille, 1802. *In*: GEOFFROY, J.-J., MAURIÈS, J.-P. & NGUYEN DUY - JACQUEMIN, M., (eds), Acta Myriapodologica. *Mém. Mus. natn. Hist. nat.*, **169** : 473-476. Paris ISBN : 2-85653-502-X.

generalizations are difficult. The main aim of this study was to test differences between the species in specific metabolic rate (SMR) and to assay the SMR - temperature relationship using almost identical experimental procedure and the same method of measurement.

MATERIAL AND METHODS

The specimens of *G. balcanica* were collected in the northwest of Greece, some 20 km from Thessaloniki about 400 m a.s.l. in June 1991 (leg. TAJOVSKY), and, after transport to our laboratory, kept for 3 weeks at 15°C in darkness. A mixture of *Quercus coccifera* and *Quercus robur* litters was used as food. Specimens of *G. marginata* were collected from a *Quercus pubescens* forest in Ruoms near Montélimar (south of France) at an altitude 400 m a.s.l. in May 1991 (leg. FROUZ) and kept on *Q. robur* litter in similar conditions as *G. balcanica*. Individuals of *G. hexasticha* were collected in a mixed oak forest near Netolice in South Bohemia at an altitude from 485 to 570 m a.s.l. in May 1991 (leg. SUSTR & TAJOVSKY), and kept on *Quercus robur* litter for 1- 3 weeks in conditions similar to those for *G. balcanica*. Oxygen consumption was measured in a Warburg respirometer over a 5-hour period; 30 minutes were allowed for thermostabilization. The respiration rate of every animal was measured successively at 5, 10, 15, and 20°C during 4 days of experiment. Animals were reared in the laboratory culture (15°C, dark, with food) for approximately 19 hours between the measurements. Seventeen individuals of *G. hexasticha* (7 males and 10 females), 15 specimens of *G. balcanica* (2 males and 13 females) and 16 individuals of *G. marginata* (7 males and 9 females), with body mass in the range of 0.030 - 0.219 g, 0.091 - 0.282 g, and 0.073 to 0.399 g, respectively, were used in the experiments. Q_{10} values were calculated according to the equation $Q_{10} = (k_1/k_2)^{10/(t1-t2)}$, where k_1 and k_2 are mean respiration rates at temperatures t1 and t2 respectively.

RESULTS

Specific metabolic rate (SMR)-temperature curves are shown in Figure 1. ANOVA indicated a significant effect of temperature on SMR in all three species ($F = 36.6$, $P < 0.01$ in *G. marginata*, $F = 40.4$, $P < 0.01$ in *G. hexasticha* and $F = 49.0$, $P < 0.01$ in *G. balcanica*). The shapes of the curves were similar in both sexes of the same species (see Table 1). An almost linear curve was observed in *G. marginata*. The increase of SMR with increasing temperature was larger from 5 to 15°C than from 15 to 20°C in *G. balcanica*. A small range of relative temperature independence (RRTI) was observed between 15 and 20°C in *G. hexasticha* (Fig. 1, Table 1).

SMR values were higher in males than in females. Differences were significant in *G. hexasticha* ($F = 5.8$, $P < 0.02$) and in *G. balcanica* ($F = 8.5$, $P < 0.01$). In *G. balcanica*, however, the comparison is disputable because of the limited number of males used in the experiment.

The SMR of *G. marginata* was significantly lower than those of *G. balcanica* and *G. hexasticha* at 5 and 15°C ($F = 14.6$, $P < 0.01$ and $F = 11.1$, $P < 0.01$ respectively).

The mean individual body mass was 0.090 g in *G. hexasticha*, 0.175 g in *G. balcanica*, and 0.187 g in *G. marginata*. Changes in body mass were not significant during the experiment ($F < 0.01$, $P > 0.9$) for any species.

TABLE 1. — Q_{10} coefficients in three species of glomerid millipedes in the temperature range from 5°C to 20°C.

Species	Temperature range					
	5-10	5-15	10-15	5-20	10-20	15-20
Glomeris hexasticha	2.0	2.3	2.6	1.9	1.8	1.2
Glomeris hexasticha males	1.9	2.3	2.9	1.8	1.8	1.1
Glomeris hexasticha females	2.3	2.3	2.3	1.9	1.8	1.3
Glomeris balcanica	2.8	3.0	3.1	2.3	2.1	1.3
Glomeris balcanica males	4.4	4.2	4.0	3.0	2.5	1.5
Glomeris balcanica females	2.7	2.7	2.7	2.1	1.9	1.3
Glomeris marginata	4.3	3.0	2.1	2.5	2.0	1.8
Glomeris marginata males	4.0	3.1	2.3	2.5	2.0	1.8
Glomeris marginata females	5.3	3.2	2.0	2.7	1.9	1.9

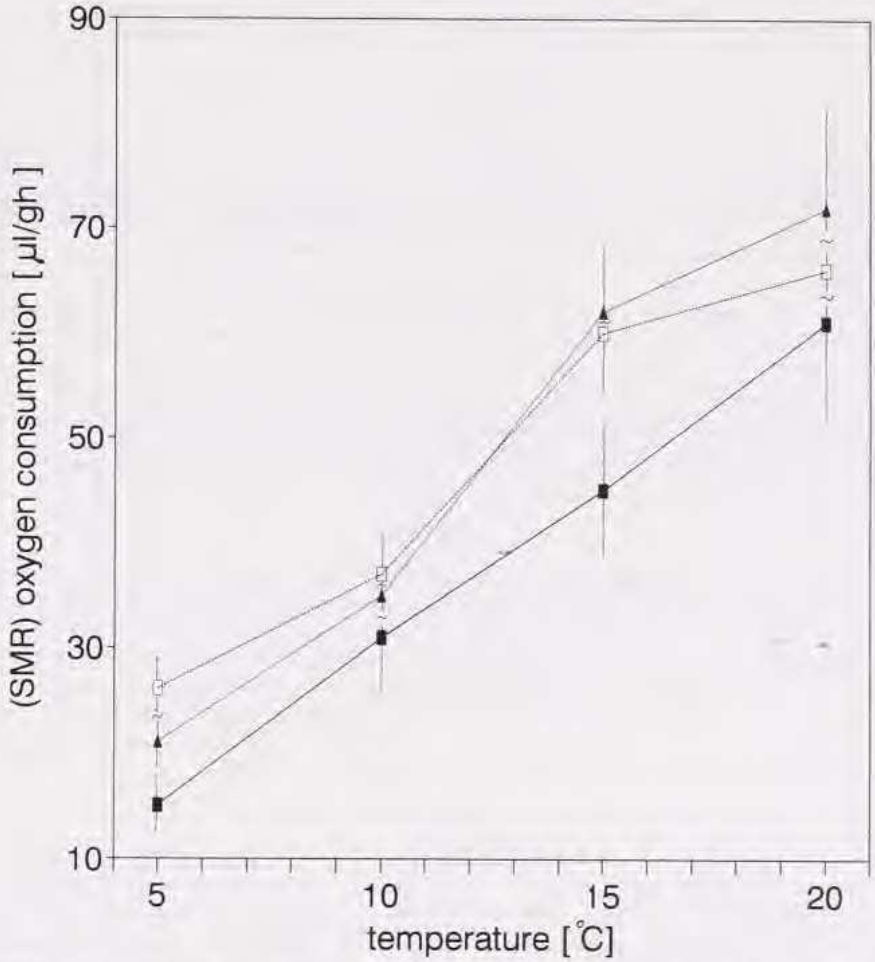

FIG. 1. — Mean SMR - temperature relationships in three species of millipedes. Errors bars: 95% confidence intervals, filled triangle: *Glomeris balcanica*, filled square: *Glomeris marginata*, empty square: *Glomeris hexasticha*.

DISCUSSION

G. marginata, in agreement with its geographical distribution, would be best adapted to an oceanic climate with relatively variable weather. The population used in this study lives in a relatively exposed, warm and dry site. Adaptation to a microclimate with frequent temperature fluctuations, as well as relatively low locomotion activity appears to have prevented *G. marginata* from establishing an RRTI (that does or does not occur in a species). A wide range of preferred temperatures (18°C to 26°C) was observed in *G. marginata* in laboratory by DUNGER & STEINMETZGER (1981). The site of collection of *G. hexasticha* has a forest microclimate without great temperature fluctuations. These conditions may have enabled the establishment of a clearly expressed RRTI between 15°C and 20°C in the species. Its prefered temperature of 20°C was reported in laboratory by DUNGER & STEINMETZGER (1981). The lack of RRTI should be expected in *G. balcanica* because of high temperature fluctuations in the soil organic layer in *Q. coccifera* formation. However, *G. balcanica* shows greater locomotion activity and irritability than *G. marginata* and *G. hexasticha*. The difference between the standard and active metabolic rate may be larger and the RRTI consequently more expressed. The combination of the above mentioned factors contributes to the establishment of the RRTI, which is less apparent in comparison to *G. hexasticha*. The placement of the RRTI (between 15°C and 20°C) corresponds

to a temperature optimum of food consumption (IATROU & STAMOU, 1989) and with Q_{10} values obtained by IATROU (1989).

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